Gearheads

Role of the Gearhead

The role of a gearhead is closely related to motor development. Originally, when the AC motor was a simple rotating device, the gearhead was mainly used to change the motor speed and as a torque amplifier. With the introduction of motors incorporating speed control functions, the primary role of the gearhead was to amplify torque. But with the wide acceptance of stepping motors and brushless DC motors to meet the requirements for control of speed and position, gearheads found new purposes, including the amplification of torque, improvement in permissible inertia and reduction of motor vibration.

Furthermore, the accurate positioning capability of motors has created a demand for high-precision, backlash-free gearheads, unlike the conventional gearheads for AC motors. Oriental Motor, keeping up with these trends, has been developing specific gearheads having optimal characteristics needed to preserve the characteristics of the motor with which it is used. Gearheads for AC motors, are designed with emphasis on high permissible torque, long life, low noise and a wide range of gear ratios. By contrast, gearheads for stepping motors are designed for highly accurate positioning, where a high degree of precision, high permissible torque and high speed operation are important. The following sections describe these gearheads in detail.

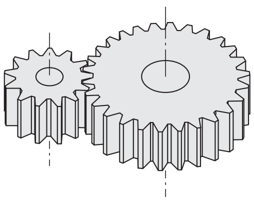
Gearheads for AC Motors

Standard AC motors have a long history, as do the gearheads used with these motors. During the course of that history, AC motors and gearheads have found a wide spectrum of applications and user needs including low noise level, high power, long life, wide range of gear ratios and resistance to environmental conditions. Oriental Motor has therefore been developing products in order to accommodate various needs.

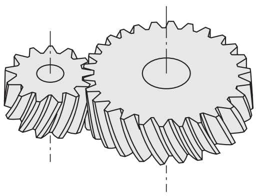
● Parallel Shaft Gearheads

Parallel shaft gearheads are the most commonly used gear systems today. Our parallel shaft gearheads employ spur gears and helical gears. Helical gears are used for low-noise, high-strength performance.

● Spur Gear
The spur gear is a cylindrical gear on which the teeth are cut parallel to the shaft.



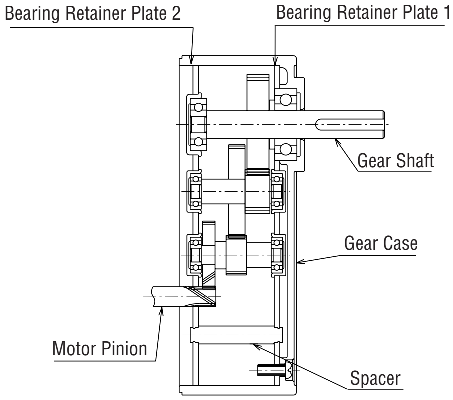
● Helical Gear
The helical gear is a cylindrical gear having teeth cut in a helical curve. Its high rate of contact, as compared to the spur gear, has the advantages of low noise and higher strength, but its axial thrust calls for careful consideration in design.



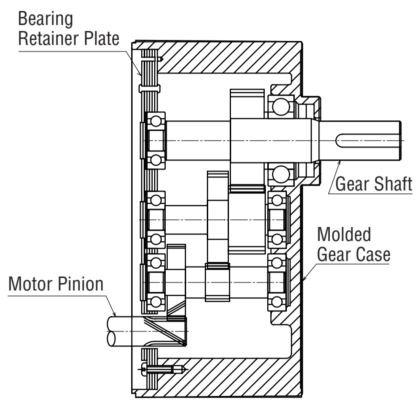
In both types of gearheads, the helical configuration is employed for the motor pinion and its mating gear. This contributes significantly to noise because of their high contact speeds, thereby achieving lower noise output.

The high-strength **GV** gearhead achieves total noise reduction by increasing the rigidity of the gear case while limiting the effect of alignment error at each shaft. The **GV** gearhead motors, with their hardened gears and larger bearings, also generate high torque, being equivalent to two to three times the level produced by the general purpose **GN** and **GU** Series motors. Moreover, the rated service life of the **GV** Series is twice that of its counterparts, meaning the **GV** gearhead will survive 20,000 hours of operation if used under the same torque commonly expected of conventional models (**GN**/**GU** Series). Indeed, the **GV** Series provides a great way to extend maintenance intervals and save energy and resources.

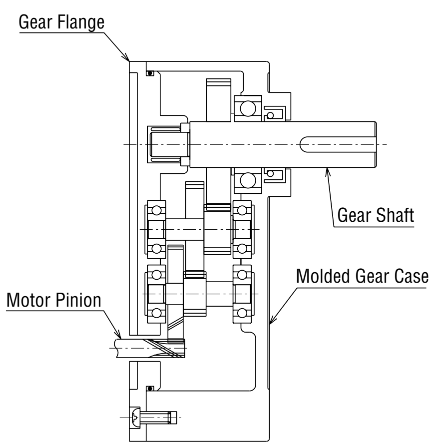
GN Gearhead



GU Gearhead



GV Gearhead



For use with general AC motors, many of which are fixed speed motors, the availability of various gear ratios suits a wide range of desired speeds. We support these motors with as many as 20 different gear ratios, ranging from 3:1 to 180:1.

● Right-Angle Gearheads (solid and hollow shafts)

The right-angle gearhead is designed to facilitate the efficient use of limited mounting space and the elimination of couplings and other power-transmission components (in the case of the hollow-shaft type). **RA** and **RH** right-angle shaft-type gearheads have worm gears, screw gears or hypoid gears.
Both right-angle gearheads incorporate right-angle gearing at the final stage, leaving the input end identical to that of the parallel shaft types. This facilitates the conversion from the parallel shaft to a right angle shaft gearhead without changing the motor.

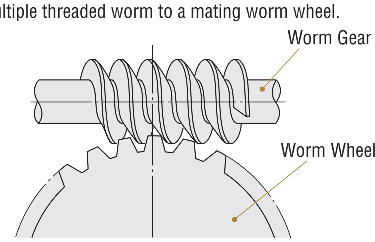
Hollow Shaft

Solid Shaft

◆ Worm Gears

The worm gear transmits power from a single or multiple threaded worm to a mating worm wheel. The worm gear's application has been limited due to its relatively low efficiency and difficulty of manufacturing. Oriental Motor has successfully incorporated the worm gear based on its right-angle property and capacity for large gear ratios, and has inproved its efficiency over conventional types by increasing the lead.

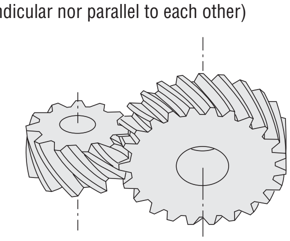
● Worm Gears
The worm gear transmits power from a single or multiple threaded worm to a mating worm wheel.

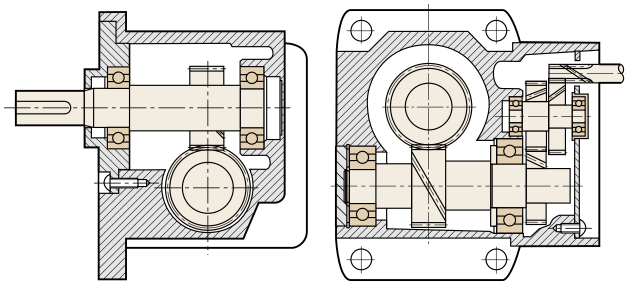


◆ Screw Gears

A single screw gear appears to be another regular helical gear. While the mating helical gears in the parallel shaft configuration have equal helix angles and contact with the helixes running in opposite directions, the screw gears are designed to contact their shafts crossing at right angles. Due to their point-to-point contact configuration, they're mainly used under relatively small loads, such as at low gear ratios with our right-angle gearheads.

● Screw Gears
These are helical gears used on offset shafts (neither perpendicular nor parallel to each other)





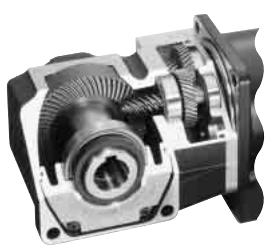
Structure of the Screw Gear

◆ Hypoid Gears

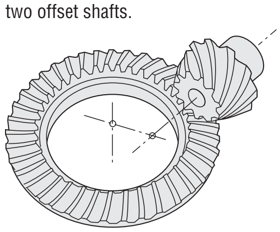
Generally, the differential gears for automotive use have been hypoid gears. Being something of a midpoint between the zero-offset bevel gear and maximum-offset worm gear, the hypoid gear achieves a combination of high strength and efficiency. The offset placement of the pinion gear allows the suppression of vibration and helps obtain higher gear ratios, as compared to the bevel gear. The hypoid gears in Oriental Motor gearheads are incorporated at the final stage, facilitating the disassembly of the gears from the motor.

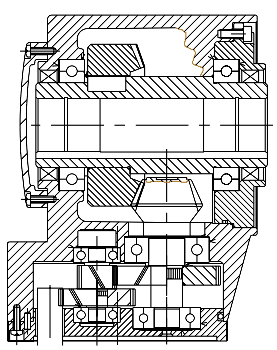
✻ Offset: In hypoid gears the two shafts do not cross but are in displaced planes, separated from each other at a right angle. The displacement is called the offset.

BH Series, hypoid gear



● Hypoid Gears
These are conical gears with curved teeth for transmitting power between two offset shafts.





Structure of the Hypoid Gear

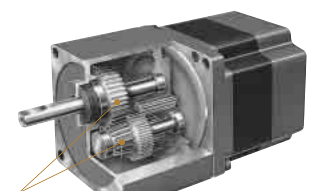
■ Stepping Motor Gears

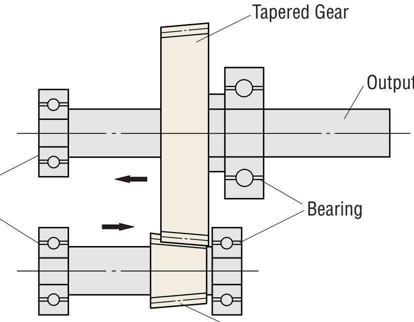
Since the stepping motor and other control motors are designed to allow accurate positioning, the gearheads used for these motors must provide the same level of accuracy. Accordingly, Oriental Motor has developed a mechanism to minimize backlash in gears used with stepping motors in order to ensure low backlash properties. The basic principles and structures of typical control motor gears are explained below.

● Taper Hobbed (TH) Gears

◆ Principle and Structure

Tapered hobbed gears are used for the final stage of the spur gear's speed reduction mechanism and the meshing gear. The tapered gear is produced through a continuous profile shifting toward the shaft. The tapered gears used at the final stage are adjusted in the direction of the arrows, as shown in the figure below to reduce backlash.



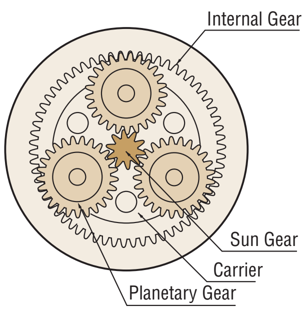


Structure of **TH** gear's final stage

● Planetary (**PN**) Gears

◆ Principle and Structure

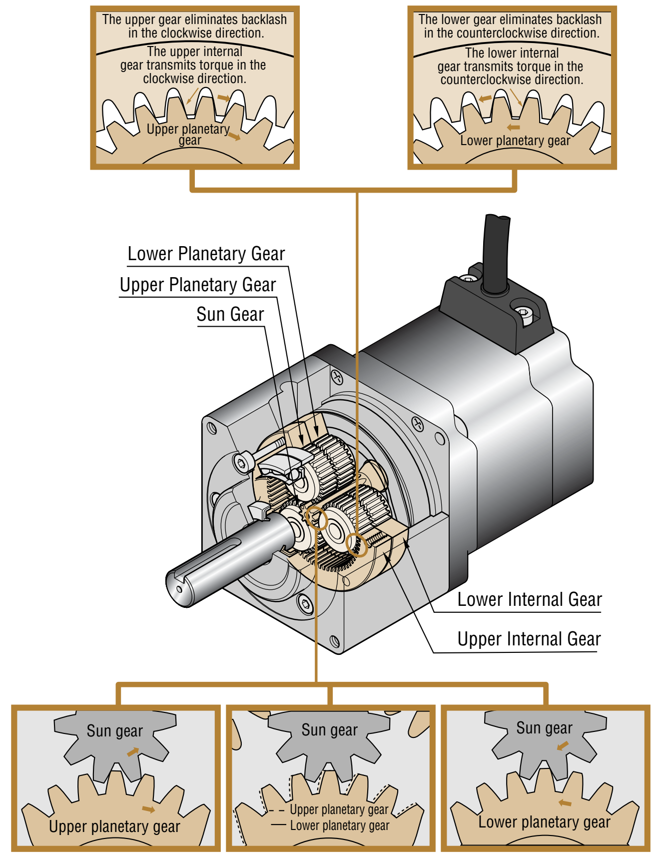
The planetary gear mechanism is comprised mainly of a sun gear, planetary gears and an internal tooth gear. The sun gear is installed on the central axis (in a single stage type, this is the motor shaft) surrounded by planetary gears enclosed in an internal tooth gear centered on the central axis. The revolution of planetary gears is translated into rotation of the output shaft via carriers.



Cross Section of a **PN** Gear

Sun Gear:	A gear located in the center, functioning as an input shaft.
Planetary Gears:	Several external gears revolving around the sun gear. Each planetary gear is attached to the carrier, onto which the gear's output shaft is securely fixed.
Internal Gear:	A cylindrical gear affixed to the gearbox, having teeth on its inside diameter.

The **PN** gear achieves the specified backlash of two arc minutes through the improved accuracy of its components and the backlash elimination mechanism. That mechanism is comprised of two sets of internal and planetary gears on the upper and lower levels with the internal gear teeth twisted in the circumferential direction. The upper level internal gears and planetary gears reduce clockwise backlash; the lower level internal gears and planetary gear reduce counterclockwise backlash.



Relationship between upper and lower planetary gears

◆ High Permissible Torque

In conventional spur-gear speed reduction mechanisms, gears mesh one to one, so the amount of torque is limited by the strength of each single gear. On the other hand, in the planetary gear speed reduction mechanism, a greater amount of torque can be transmitted, since torque is distributed through dispersion via several planetary gears. The torque applied to each gear in the planetary gear speed reduction mechanism is obtained through the following formula:

$$T=k\,\frac{T'}{n}$$

T: Torque applied to each planetary gear (N·m)

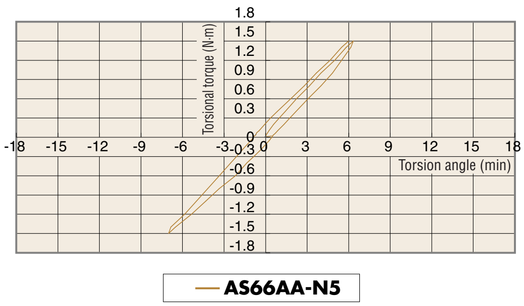
T': Total torque transference (N·m)
n: Number of planetary gears
k: Dispersion coefficient

The dispersion coefficient indicates how evenly the torque is dispersed among the individual planetary gears. The smaller the coefficient, the more evenly the torque is dispersed and the greater the amount of torque that can be transferred. To evenly distribute the transferred torque, each component must be accurately positioned.

◆ Torsional Rigidity

When a load is applied to the **PN** gear's output shaft, displacement (torsion) is proportional to the spring constant. The graph below shows data for torsion angles measured by gradually increasing and decreasing the load on the output shaft in the forward and backward directions.

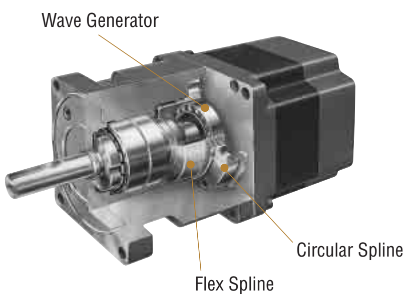
Torsional rigidity of **PN** geared types



● Harmonic (HG) Gears

◆ Principle and Structure

The harmonic gear offers unparalleled precision in positioning and features a simple construction utilizing the metal's elastomechanical property. It is comprised of three basic components: a wave generator, flex spline and circular spline.



Wave Generator

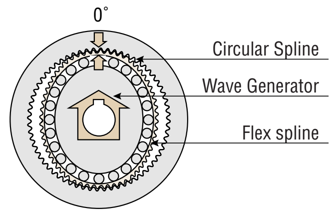
The wave generator is an oval-shaped component with a thin ball bearing placed around the outer circumference of the oval cam. The bearing's inner ring is attached to the oval cam, while the outer ring is subjected to elastic deformation via the balls. The wave generator is mounted onto the motor shaft.

Flex Spline

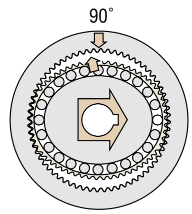
The flex spline is a thin, cup-shaped component made of elastic metal, with teeth formed along the outer circumference of the cup's opening. The gear's output shaft is attached to the bottom of the flex spline.

Circular Spline

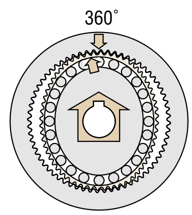
The circular spline is a rigid internal gear with teeth formed along its inner circumference. These teeth are the same size as those of the flex spline, but the circular spline has two more teeth than the flex spline. The circular spline is attached to the gearbox along its outer circumference.



The flex spline is bent into an oval shape by the wave generator. The teeth at the long axis of the oval mesh with the circular spline, while the teeth at the short axis of the oval are completely separate from it.



Rotating the wave generator (input) clockwise while keeping the circular spline fixed in position will subject the flex spline to elastic deformation, causing a gradual shift in the point of engagement between the circular spline and flex spline.



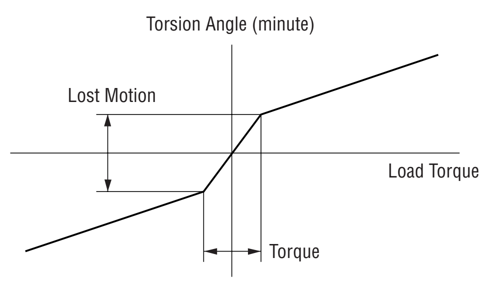
When the wave generator completes one revolution, the flex spline has rotated two fewer teeth than the circular spline has, resulting in the movement of flex spline for the difference in the tooth count (two teeth) in the opposite direction of the wave generator's rotation (i.e., counterclockwise). This movement translates into output, thereby reducing the speed.

◆ Precision

Unlike conventional spur gears, the harmonic gear is capable of averaging the effects of tooth pitch errors and accumulated pitch errors to the rotational speed, thus achieving highly precise, zero-backlash performance. However, the gear's own torsion may become the cause of a problem when performing ultra-high precision positioning at an accuracy of two arc minutes or less. When using a harmonic gear for ultra-high precision positioning, remember the following three points.

Lost Motion

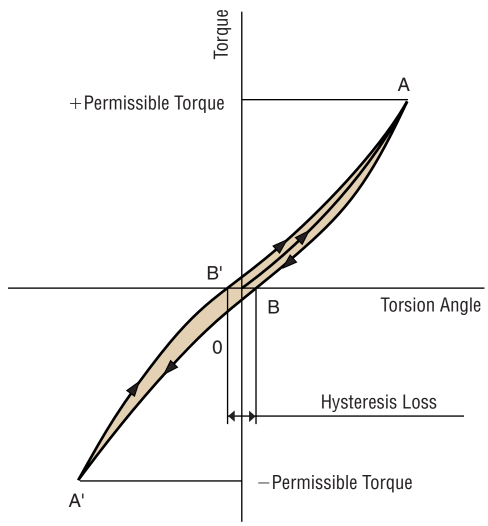
Lost motion is the total value of the displacement produced when about five percent of permissible torque is applied to the gear's output shaft. Since harmonic gears have no backlash, the measure indicating the gear's precision is represented as lost motion.



Hysteresis Loss

When torsion torque is gradually applied to the gear output shaft until it reaches the permissible torque in the clockwise or counterclockwise direction, the angle of torsion will become smaller as the torque is reduced. However, the angle of torsion never reaches zero, even when fully returned to its initial level. This is referred to as "hysteresis loss," as shown by B-B' in the figure.

Harmonic gears are designed to have a hysteresis loss of less than two minutes. When positioning from the clockwise or counterclockwise direction, this hysteresis loss occurs even with a frictional coefficient of 0. When positioning to two minutes or less, positioning must be done from a single direction.



Torsion Angle and Torque Characteristics

Torque and Torsion Characteristics

Displacement (torsion) is produced by the gear's spring constant when a load is applied to the output shaft of the harmonic gear. The amount of this displacement, which is caused when the gear is driven under a frictional load, is the same as the value when the motor shaft is held fixed and torsion (torque) is applied to the gear's output shaft. The amount of displacement (torsion angle) can be estimated through use of an equation, as shown below.

Calculation method

The harmonic gear's torsion angle/torque characteristic curve is not linear, and the characteristics can be expressed in one of the following three equations depending on the load torque:

1. Load torque T_L is T_1 or less.

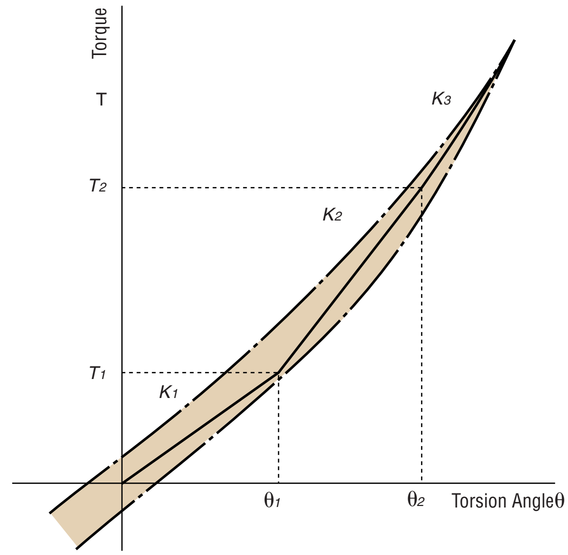
$$\theta = \frac{T_L}{K_1} \text{ [min.]}$$

2. Load torque T_L is greater than T_1 but not larger than T_2.

$$\theta = \theta_1 + \frac{T_L - T_1}{K_2} \text{ [min.]}$$

3. Load torque T_L is greater than T_2.

$$\theta = \theta_2 + \frac{T_L - T_2}{K_3} \text{ [min.]}$$



Torsion Angle and Torque Characteristics

Torsion angles obtained by these equations are for individual harmonic gears.

Values for Determining Torsion Angle

Item / Model	Gear ratio	T_1 lb-in (N·m)	K_1 lb-in/min (N·m/min.)	θ_1 min	T_2 lb-in (N·m)	K_2 lb-in/min N·m/min.	θ_2 min.	K_3 lb-in/min N·m/min.
ASC34-H50	50	13.2 (1.5)	20 (2.3)	—	—	—	—	—
ASC34-H100	100	17.7 (2)	23 (2.6)	—	—	—	—	—
AS46-H50 **ASC46-H50** **RK543-H50**	50	7 (0.8)	5.6 (0.64)	1.25	17.7 (2)	7.6 (0.87)	2.6	8.2 (0.93)
AS46-H100 **ASC46-H100** **RK543-H100**	100	7 (0.8)	6.9 (0.79)	1.02	17.7 (2)	8.7 (0.99)	2.2	11.3 (1.28)
AS66-H50 **ASC66-H50** **RK564-H50**	50	17.7 (2)	8.7 (0.99)	2	61 (6.9)	12.1 (1.37)	5.6	14.6 (1.66)
AS66-H100 **ASC66-H100** **RK564-H100**	100	17.7 (2)	12.1 (1.37)	1.46	61 (6.9)	15.6 (1.77)	4.2	18.5 (2.1)
AS98-H50 **RK596-H50**	50	61 (7)	33 (3.8)	1.85	220 (25)	46 (5.2)	5.3	59 (6.7)
AS98-H100 **RK596-H100**	100	61 (7)	41 (4.7)	1.5	220 (25)	64 (7.3)	4	74 (8.4)

Useful Life of a Gearhead

The useful life of a gearhead is reached when power can no longer be transmitted because the bearing's mechanical life has ended. Therefore, the actual life of a gearhead varies depending on the load size, how the load is applied, and the allowable speed of rotation. Oriental Motor defines service life under certain conditions as "rated lifetime," based on which the useful life under actual operation is calculated according to load conditions and other factors.

Rated Lifetime

Oriental Motor defines the rated lifetime as the useful life of a gearhead under the following operating conditions:

Torque: Permissible torque
Load: Uniform continuous load
Input rotational speed: Reference input rotational speed
Rotational speed at the rated lifetime of each gear type
Overhung load: Permissible overhung load
Thrust load: Permissible thrust load

Table 1: Rated Lifetime per Gear Type

Series/Motor Type	Gear Type	Reference-Input Rotational Speed	Rated Lifetime (L1)
αSTEP	**PN** geared type	3000 r/min	5000 hrs.
	TH geared type	1500 r/min	
	HG geared type		
RK Series	**PN** geared type	3000 r/min	
	TH geared type	1500 r/min	
	HG geared type		
5-phase **CSK** Series	**TH** geared type		
2-phase **CSK** Series	**SH** geared type		
2-phase **PK** Series	**SH** geared type		
PMC Series	**MG** geared type	3000 r/min	5000 hrs.
	HG geared type		2500 hrs.
AC Motor Brushless DC Motor	**GN**, **GU** gear type	1500 r/min	5000 hrs.
	BH (Pararell Shaft) combination type		
	GFB, **GFH**, **6GH** combination type	3000 r/min	
	GV, **GVH**, **GVR** combination type	1500 r/min	10000 hrs.
	BH (right angle) combination type		

Estimating Lifetime

Lifetime under actual conditions of use is calculated based on the permissible rotational speed, load size and load type, using the following formula:

$$\text{L (lifetime)} = L_1 \times \frac{K_1}{(K_2)^3 \times f} \text{ [h]}$$

L_1: Rated lifetime [hrs.]
See Table 1 above to find the applicable rated lifetime for the gear.

K_1: Rotational speed coefficient
The rotational speed coefficient (K_1) is calculated based on the reference input rotational speed listed in Table 1 above and the actual input rotational speed.

$$K_1 = \frac{\text{Reference input rotational speed}}{\text{Actual input rotation speed}}$$

K_2: Load factor
The load factor (K_2) is calculated based on actual operating torque and the allowable torque for each gear. The average torque may be considered operating torque if the gear is subjected to load while starting and stopping only, as when driving an inertial body. The calculation of average torque is explained later in this section.

$$K_2 = \frac{\text{Operating torque}}{\text{Permissible torque}}$$

Permissible torque is per the specified values listed in the product catalog and operating manual.

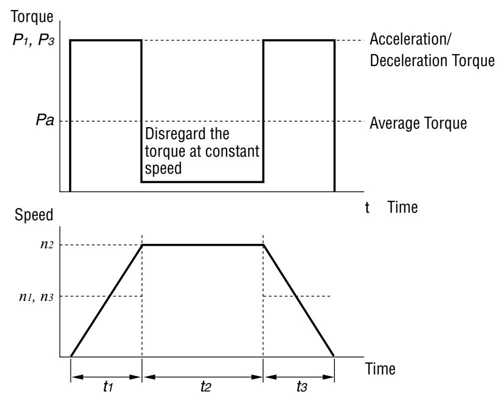
f: Load-type factor
The factor (f) may be determined based on load type, using the following examples as a reference:

Load Type	Example	Factor (f)
Uniform Load	• One-way continuous operation • For driving belt conveyors and film rollers that are subject to minimal load fluctuation.	1.0
Light Impact	• Frequent starting and stopping • Cam drive and inertial body positioning via stepping motor	1.5
Medium Impact	• Frequent instantaneous bidirectional operation, starting and stopping of reversible motors • Frequent instantaneous starting and stopping of brushless motors	2.0

Notes regarding the effects of overhung load and thrust load
- The above estimated lifetime is calculated according to the overhung and thrust loads, which are in proportion to a given load factor. For example, if the load factor is 50%, the lifetime is calculated using 50% overhung and thrust loads.
- The actual life of a gearhead having a low load factor and a large overhung or thrust load will be shorter than the value determined through the above equation.

How to Obtain the Average Torque

The stepping motor is used for intermittent operation of an inertial body, such as driving an index table and arm. If the stepping motor is used in such an application, the average torque shall be considered the operating torque, as described below. The load factor for driving an inertial body using an AC or DC brushless motor shall be 1.0.



$$Pa = \sqrt[3]{\frac{(P_1{}^3 \times n_1 \times t_1) + (P_3{}^3 \times n_3 \times t_3)}{(n_1 \times t_1) + (n_2 \times t_2) + (n_3 \times t_3)}}$$

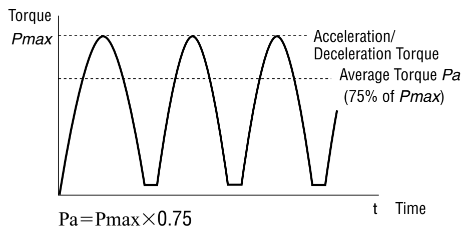
n_1, n_3 shows average speed in the t_1, t_3 periods.
In the above chart, $n_1 = n_3 = 1/2\ n_2$

◆ Driving an Inertial Load Directly

The previous graph shows torque generated in order to drive an inertial body over a long operating cycle. Friction load caused by bearings and other parts during constant-speed operation are negligible.

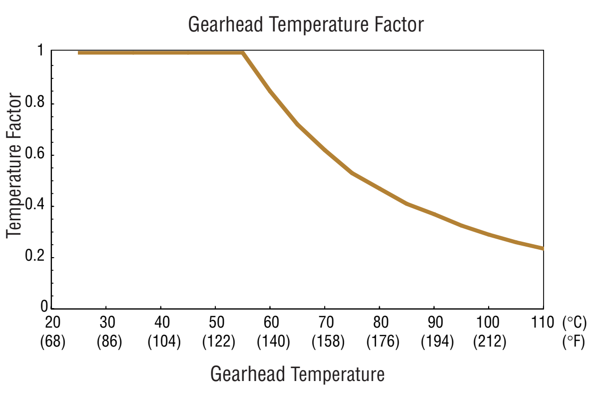
◆ Driving an Inertial Load using an Arm or Similar Object

When driving an arm or similar object, the gearhead may be subjected to load fluctuation as shown in the graph.
For example, such load fluctuation will occur when driving a double-joint arm or moving an arm in the vertical direction. In such an application, the average torque shall be 75 percent of the maximum acceleration/deceleration torque, as shown in the equation below.



● Operating Temperature

An increase in gearhead temperature affects the lubrication of the bearing. However, since the effect of temperature on gearhead life varies according to the condition of the load applied to the gearhead bearings, model number and many other factors, it is difficult to include the temperature effect in the equation to estimate the lifetime, which was described earlier.
The graph below shows the temperature effect on the gearhead bearings. The gearhead life is affected when the gearbox's surface temperature is 131°F (55˚C) or above.



Notes:
In some cases, a lifetime of several tens of thousands of hours may be obtained from the calculation. Use the estimated life as a reference only. The above life estimation is based on the bearing life. An application in excess of the specified value may adversely affect parts other than the bearings. Use the product within the range of specified values listed in the product catalog or operating manual.

■ Advantages of Geared Stepping Motors

Geared stepping motors are designed mainly for speed reduction, higher torque and high resolution, as well as the following purposes:

- Downsizing (smaller frame size and lower weight)
- High rigidity (motor less prone to the effects of fluctuation in friction load)
- Shorter positioning time for improved safety against inertial loads
- Low vibration

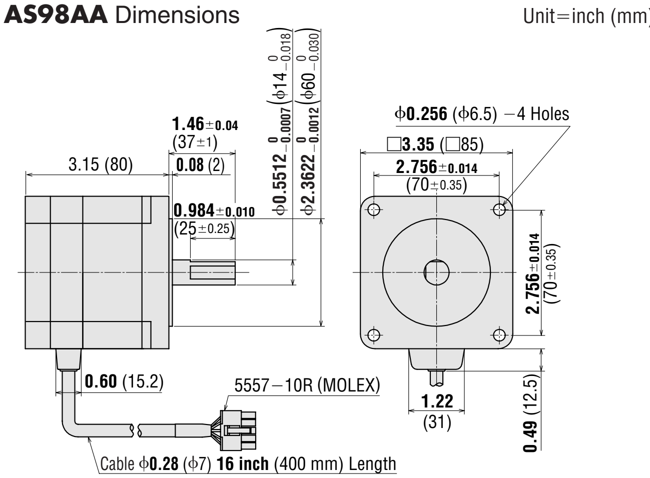
To further explain these four purposes using examples, comparisons will be made below between a motor (no gearhead) and a geared motor, both of which have similar output torque and allowable torque. If no problem exists in terms of rotational speed, the motor may be replaced by the geared motor.

● Downsizing

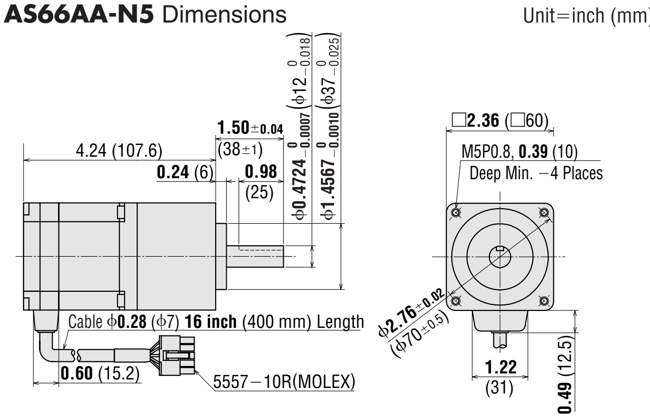
A motor may be switched to a smaller geared motor as long as both motors operate at equivalent torque. For example, a motor with a frame size of □3.35 in. (□85 mm) can be replaced by the geared motor with a frame size of □2.36 in. (□60 mm), thereby reducing the weight from 4.0 lb. (1.8 kg) to 3.3 lb. (1.5 kg) (comparison between **AS98AA** and **AS66AA-N5**).

Item \ Product Name	Motor	Geared Motor	
	AS98AA	**AS66AA-T7.2**	**AS66AA-N5**
Frame Size in. (mm)	□3.35 (□85)	□2.36 (□60)	□2.36 (□60)
Gear Ratio	—	7.2 : 1	5 : 1
Maximum Holding Torque Permissible Torque lb-in (N·m)	17.7 (2)	22 (2.5)	30 (3.5)
Backlash arc min	—	15	2
Output Shaft's Rotation Speed r/min	0~4000	0~250	0~600

AS98AA Dimensions Unit=inch (mm)



AS66AA-N5 Dimensions Unit=inch (mm)

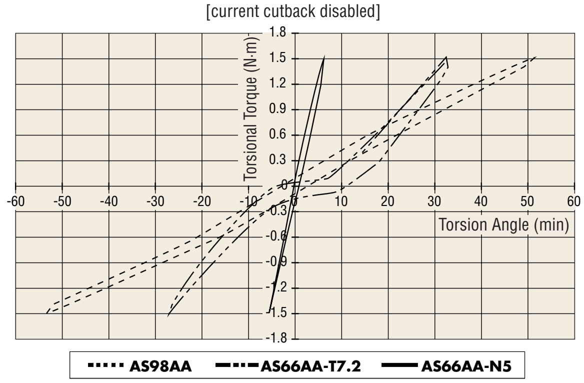


● High Rigidity (making the motor less prone to the effects of fluctuation in friction load)

With the motor's power on, the output shaft is subjected to torsion applied externally to measure the amount of displacement (torsion angle) for comparison of rigidity. At a given torque, the smaller displacement (torsion angle) means higher rigidity. For example, the **AS66AA-T7.2** geared motor receives backlash effects at a light load of 0.88 lb-in (0.1N·m) torsional torque, but becomes less prone to twisting than the **AS98AA** as the torsion increases. The **AS66AA-N5** motor receives little in the way of backlash effects at a light load, and maintains high rigidity throughout the entire torque range.

Comparison of Torsional Rigidity between Motor and Geared Motor

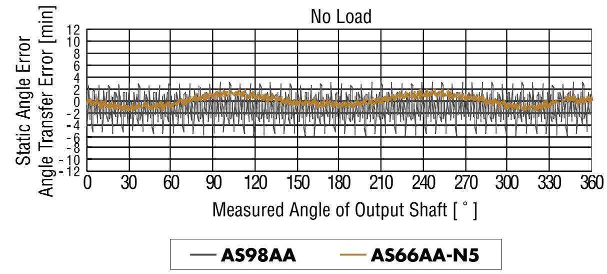
[current cutback disabled]

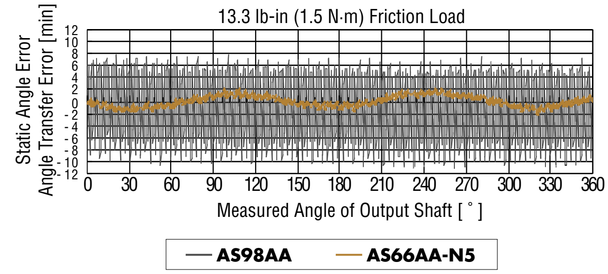


Positioning accuracy against the fluctuating friction load is an important determinant of motor rigidity. Positioning accuracy can be measured by the static angle error (angle transfer error for the geared motor). The static angle error (angle transfer error) refers to the difference between the theoretical angle of rotation (this is the rotation angle calculated from the number of input pulses) and the actual output shaft's rotation angle. The error closer to zero represents higher rigidity. The **AS98AA** motor and **AS66AA-N5** geared motor are compared by measuring the static angle error (angle transfer error) under no load and a friction load, at 0.36˚ intervals for a single revolution. The results of comparison show that motor's static angle error significantly increases when the load is applied while the geared motor's angle transfer error barely changes, even when the load is applied. In other words, the geared motor is more resistant to fluctuations in friction load, thus achieving more stable positioning. This feature applies to any type of geared motor.

Therefore, geared motors are more effective for positioning operation for up/down motion and other applications in which friction load fluctuates due to the changing quantity and weight of the workpiece(s).

Comparison of Static Angle Error (angle transfer error) between **AS98AA** and **AS66AA-N5**



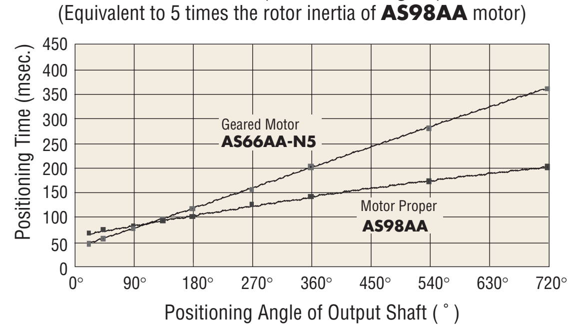


● Shorter Positioning Time for Improved Safety Against Load Inertia

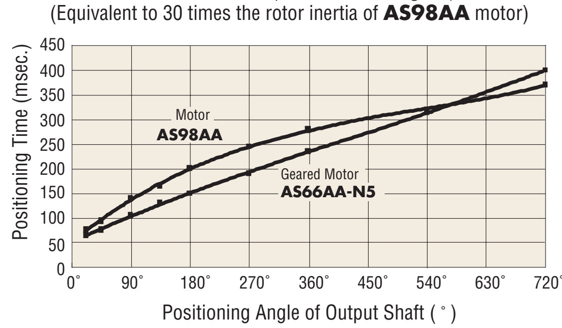
To drive a large load inertia within a short period of time, the use of a geared motor will achieve a shorter positioning time than a motor.

Assume that the **AS98AA** motor is connected to inertia loads that are 5 and 30 times the motor's rotor inertia, respectively, and that each of these inertia loads is connected to the **AS66AA-N5** geared motor. The shortest positioning time for each rotational speed is measured as shown in the graphs below.

J_L =38 oz-in² (7,000×10⁻⁷ kg·m²)
(Equivalent to 5 times the rotor inertia of **AS98AA** motor)



J_L = 1230 oz-in² (42,000×10⁻⁷ kg·m²)
(Equivalent to 30 times the rotor inertia of **AS98AA** motor)



The geared motor is more effective in reducing the positioning time for a smaller positioning angle and a larger load inertia. The geared motor tends to achieve shorter positioning time in a wider range of positioning angles with a larger load inertia.

The geared motor reduces positioning time for the following reasons:

- Load inertia to the motor shaft can be reduced through the use of gears, thereby ensuring quick acceleration and deceleration startups.

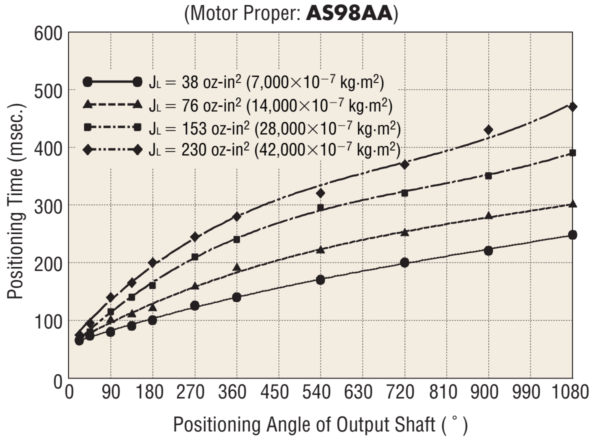
$$J_M \text{ (motor shaft inertia)} = \frac{J_G \text{ (gear shaft inertia)}}{I^2 \text{ (gear ratio)}}$$

  This formula indicates that a load inertia that is 30 times the rotor inertia of the motor can be reduced to nearly four times the motor shaft inertia when connected to the geared motor with a ratio of 5:1.

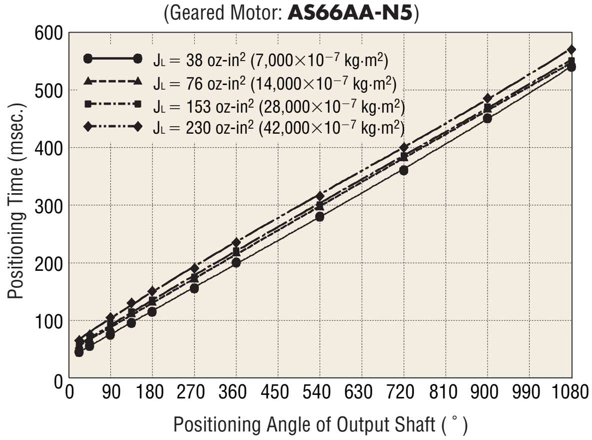
- Positioning for a small positioning angle is completed before the motor reaches the high rpm range (triangle drive instead of trapezoidal drive).

Another advantage of the geared motor is its ability to maintain a consistent positioning time regardless of changes in load inertia. The graphs below show changes in the shortest positioning time of the motor and geared motor when each motor is subjected to variations in load inertia.

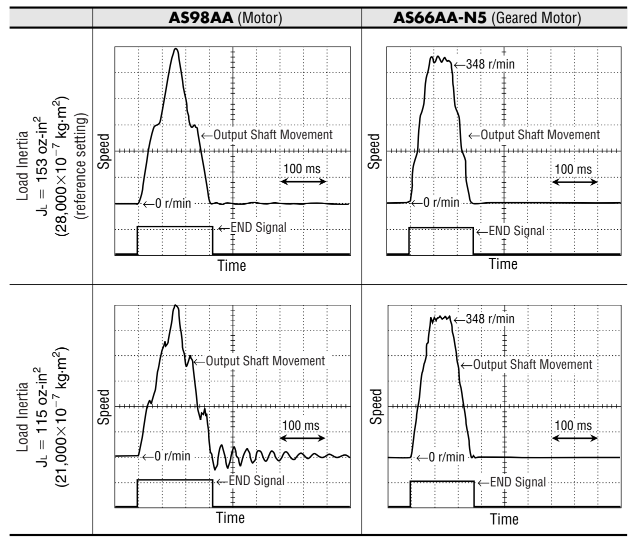
Changes in Positioning Time due to Variations in Load Inertia
(Motor Proper: **AS98AA**)



Changes in Positioning Time due to Variations in Load Inertia
(Geared Motor: **AS66AA-N5**)



While the shortest positioning time of the motor changes significantly with the increase in load inertia, that of the geared motor shows little change. In other words, the geared motor is capable of driving a larger load inertia within the most consistent, shortest positioning time.
No matter how quickly a motor can perform positioning, the failure to achieve stable operation against load inertia fluctuations may result in a problem. Therefore, it is also important to study how the operation waveform is shaped according to fluctuations in load inertia.
Connect the same inertial body to both the motor and geared motor, under the operating conditions that allow for the shortest positioning. Then switch the inertial body to a smaller load inertia without changing the operating conditions. The operation waveform for each of these cases is shown in the graphs below.



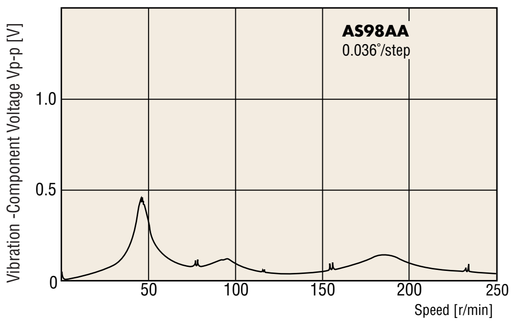
Even under the operating conditions that are optimized to reduce damping with a given load inertia, the damping characteristics of the motor will deteriorate with fluctuations in load inertia. For the motor it is therefore necessary to reset the operating conditions for optimal performance each time the load inertia fluctuates. On the other hand, the geared motor's damping characteristics change little with fluctuations in load inertia, thereby ensuring steady operation.

Low Vibration

Vibration characteristics are represented in electric voltage, into which the vibration width of the output shaft in rotary motion is converted. Vibration of the geared motor can be reduced for the following reasons:

- The motor's own vibration can be reduced in accordance with the gear ratio.
- The low speed vibration range can be avoided, since the motor is run at higher speeds.
- Because the motor is smaller, its own vibration is reduced accordingly.

Vibration Characteristic of **AS98AA**



Vibration Characteristic of **AS66AA-N5**